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CYTOTAXONOMIC INVESTIGATIONS IN THE *PANICUM MAXIMUM* JACQ. COMPLEX
II. STUDIES ON EPIDERMAL PATTERN

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ABSTRACT

In an earlier publication, the authors (Jauhar and Joshi, 1966) morphologically described 20 collections of guinea grass (*Panicum maximum*) and grouped the material into five distinct types. The present paper records observations on foliar epidermal patterns in this material. The classification on the basis of dermotypic features studied in this paper conforms to the one based on morphological characters.

INTRODUCTION

The usefulness of foliar epidermal patterns as an aid in classification has been elegantly demonstrated in recent years (Stebbins, 1956; Constance, 1957; Metcalfe, 1959; Lea and Reynolds, 1961; Leigh, 1961; Jauhar, 1963, 1967, and others). Jauhar (1963) and Jauhar & Joshi (1966) described the morphological features of 20 indigenous and exotic collections of *Panicum maximum* and on this basis grouped them into five distinct types. The leaf epidermal patterns of these types are described in the present paper as a part of the cytotaxonomic studies undertaken in this complex species. It was observed that the distinctive features of the epidermal pattern could serve as a supplementary aid in classification of this taxon.

MATERIAL AND METHODS

The twenty collections of *P. maximum* from different parts of the country and from abroad studied earlier morphologically (*see* Jauhar, 1963; Jauhar & Joshi, 1966) were taken up for the present investigation.

The methods of scraping and staining of epidermal peels standardised earlier (Jauhar, 1963, 1967) were employed and proved very useful. A little modification of Prat's (1948) technique gave much better results. Central 5 cm portions of leaves were fixed in formalin-acetic-alcohol. The leaf-bits were washed in water and placed in shallow Petri-dishes containing 70 per cent alcohol. Gentle scraping with the help of sharp blade was continued to remove all chlorophyllous and vascular tissue till very thin peels were left. Scraping was started from the upper surface when lower epidermis was required and *vice-versa*. The piece of epidermis was turned up side down for microscopic examination. Alcohol, being a solvent for chlorophyll, facilitates the removal of chlorophyllous tissue. Alcohol in the Petri-dish was changed after two leaf-bits were scraped. As a caution against drying of the leaf-bits, the addition of a few ml. of glycerol to alcohol proved useful.

The epidermal peels by the above modified Prat's technique were stained with 0.5 per cent safranin dissolved in 50 per cent alcohol and, after a brief washing in water, were mounted in glycerol.

OBSERVATIONS

The leaf epidermal patterns in the collections of *P. maximum* studied here broadly conform to the Panicoid-type described by De Wet (1956) and Stebbins (1956), in which the cells of the epidermal tissue are disposed in several parallel rows comprising "long cells" interspersed with "short cells", and constitute the major portion of the epidermal area.

In *P. maximum*, the "long cells" are rather short, especially as compared to those in *P. coloratum* (Jauhar, 1963) and altogether lack in cuticularisation. In the 20 collections of *P. maximum* reported in this paper, the "long cells" and the "short cells" vary in shape and dimensions and a wide range of variation is met with in respect of the extent of rippling of the walls of the "long cells" and also with regard to the number per unit area and the size of stomata on the adaxial and abaxial surfaces of the leaf blade (Table I and Figs. 1-6).

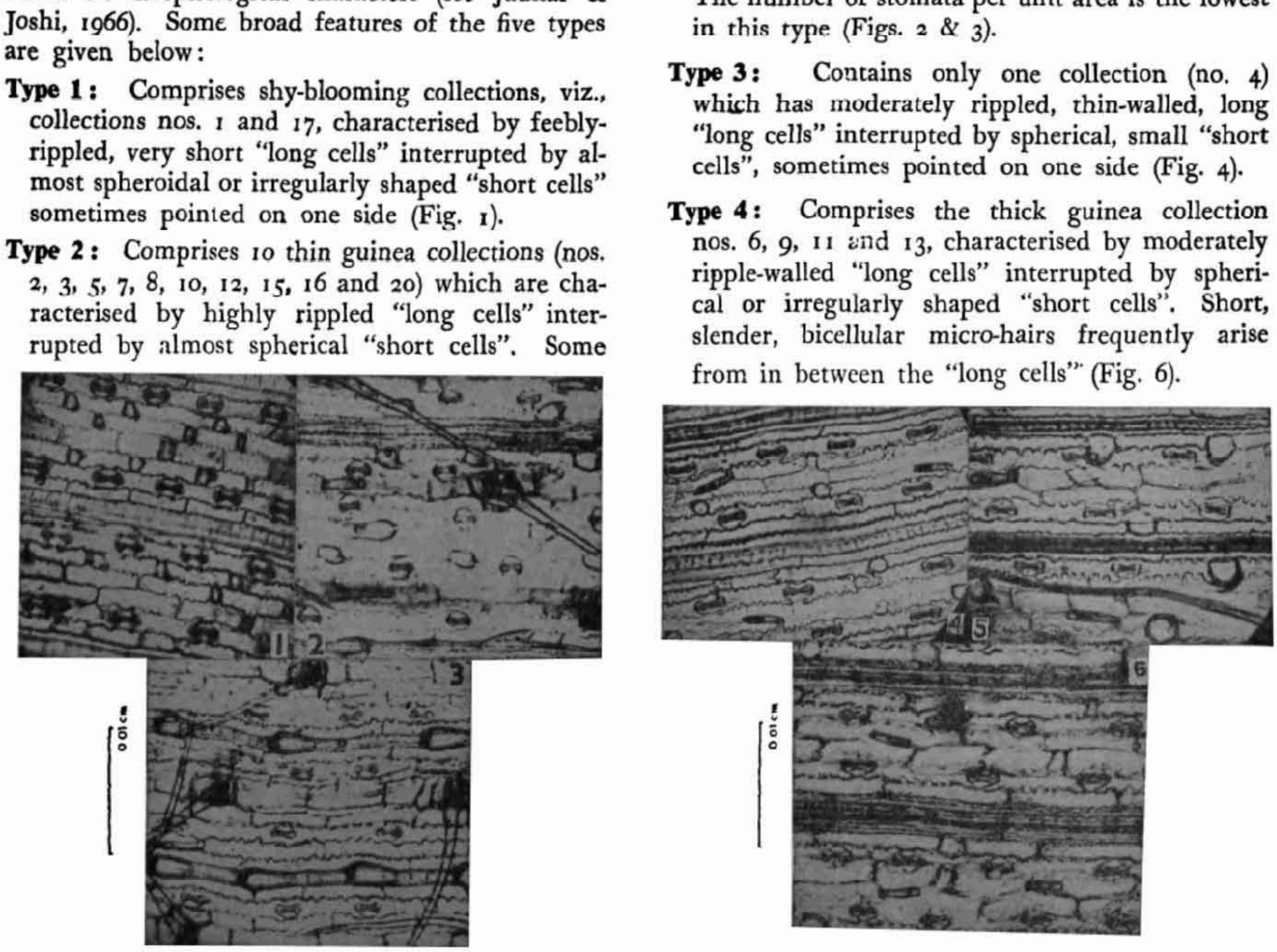
Interestingly enough, the 20 collections can, on the basis of epidermal features, be grouped into five broad types and this grouping coincides with that based on morphological characters (*see* Jauhar & Joshi, 1966). Some broad features of the five types are given below:

Type 1: Comprises shy-blooming collections, viz., collections nos. 1 and 17, characterised by feebly-rippled, very short "long cells" interrupted by almost spheroidal or irregularly shaped "short cells" sometimes pointed on one side (Fig. 1).

Type 2: Comprises 10 thin guinea collections (nos. 2, 3, 5, 7, 8, 10, 12, 15, 16 and 20) which are characterised by highly rippled "long cells" interrupted by almost spherical "short cells". Some small, slender, somewhat rectangular, bicellular micro-hairs arise from in between the long cells. The number of stomata per unit area is the lowest in this type (Figs. 2 & 3).

Type 3: Contains only one collection (no. 4) which has moderately rippled, thin-walled, long "long cells" interrupted by spherical, small "short cells", sometimes pointed on one side (Fig. 4).

Type 4: Comprises the thick guinea collection nos. 6, 9, 11 and 13, characterised by moderately ripple-walled "long cells" interrupted by spherical or irregularly shaped "short cells". Short, slender, bicellular micro-hairs frequently arise from in between the "long cells" (Fig. 6).



Figs. 1-6 : Epidermal patterns in some types of *Panicum maximum*

1. Abaxial pattern in Type 1 showing thin, feebly ripple-walled, short "long cells" interrupted by somewhat spheroidal "short cells." Note the high frequency of stomata.
2. Adaxial pattern in Type 2 showing small, almost globular stomates. Long cells are interrupted by big, spherical "short cells". Some long hairs which cover the entire foliar surface and some rectangular micro-hairs are seen.
3. Abaxial pattern in Type 2 showing thin, highly ripple-walled "long cells" and long hairs which cover the surface.
4. Abaxial pattern in Type 3 showing thin and ripple-walled, short "long cells" interspersed by short, spherical, pointed "short cells". Note rectangular micro-hairs.
5. Abaxial pattern in Type 5 showing thin, highly ripple-walled "long cells" interrupted by large, almost spherical "short cells". Note large microhairs, and very long hairs scattered on the surface.
6. Abaxial pattern in Type 4 showing mildly rippled thin-walled "long cells" and somewhat spheroidal or irregularly-shaped "short cells". Rectangular micro-hairs are also seen.

Type 5: Consists of only one, highly pubescent collection, no. 14. The epidermal pattern is almost similar to the one described for type 2 above, except for the long and somewhat broader micro-hairs (Fig. 5).

Some further details of the epidermal patterns of the different types are given below:

Type 1: On the abaxial epidermis the "long cells" are short ($68.8\,\mu$), rectangular in shape and mildly ripple-walled, feeble undulations sometimes not extending to the entire length of their walls (Fig. 1). These long cells are interrupted by small, almost spheroidal "short cells" pointed on one side. Some rectangular, slender denticules or micro-hairs emerge from in between the "long cells".

After every 2-3 layers of "long cells" stomata are linearly arranged in parallel rows. The frequency of stomata per unit area was found to be much more on the abaxial epidermis (28.5) than on the adaxial epidermis (20.8).

Type 2: The epidermal pattern in this type comprising the thin, hirtellus-leaved collections is characterised by highly ripple-walled "long cells", very deep and wide, sometimes zig-zag, undulations occurring throughout the length of the anticlinal and sometimes also the transverse walls (Fig. 2). These long cells are mediated by large, almost spherical "short cells" whose diameter is generally about 1½ to 2 times the normal width of the "long cells". Long, unicellular hairs originate near the stomata or in between the two stomata, serving probably as a natural contrivance to check transpiration (Figs. 2 & 3). Quite frequently, long, slender, bicellular denticules or micro-hairs are seen to emerge from in between the "long cells" (Fig. 2). Rarely, short, club-shaped, multi-cellular protrusions develop from some of the siliceous cells near the stomata.

On the whole the frequency of stomata per unit area was found to be very low in this type (Table I). The stomata on the adaxial epidermis being comparatively less in length (mean = 20.1 μ) and more in breadth (mean=14.2 μ) offered an almost globular appearance (stomatal index = 1.42). The stomatal dimensions were somewhat more in abaxial epidermis; their dimensions on an average measured 22.5 μ × 17.9 μ, the average stomatal index being 1.25.

Type 3: Here the epidermal pattern is made up of moderately rippled, thin walled "long cells", interrupted by short, spherical "short cells", sometimes pointed on one side. Short, slender, bicellular micro-hairs frequently emerge from in between the "long cells" (Fig. 4).

The number of stomata per unit area was almost the highest in this type (Table I).

Type 4: The "long cells" are moderately rippled and are interrupted by large, spherical or sometimes irregularly-shaped "short cells" (Fig. 6).

This type has a large number of stomata per unit area both on the adaxial as well as abaxial epidermii (Table I).

Type 5: As in Type 2 described above, the "long cells" in this type also are highly ripple-walled and sometimes zig-zag walled. The long cells are interrupted by large, almost spheroidal, short cells (Fig. 5). The slender, bicellular, almost rectangular micro-hairs arising from in between the long cells are somewhat longer and broader than those of the type 2.

Long hairs originate from in between the stomata in this type also. The number of stomata per unit area was found to be the lowest both on the adaxial as well as on the abaxial surfaces (Table I).

TABLE I

Distinctive features of leaf epidermal pattern in the different types of *Panicum maximum*

Character		Type 1	Type 2	Type 3	Type 4	Type 5	C. D. (P=0.05)
Stomata:							
Mean number per unit area	Adaxial	20.8	17.9	27.4	24.7	16.6	1.46
	Abaxial	28.5	20.2	27.8	27.7	19.1	1.37
Mean length (μ)	Adaxial	22.1	20.4	21.8	19.0	19.6	0.87
	Adaxial	22.5	22.6	23.3	24.3	22.2	1.00
Mean width (μ)	Adaxial	13.2	13.9	13.3	12.6	13.5	0.60
	Adaxial	12.9	18.1	13.7	13.8	14.5	0.65
Mean stomatal index	Adaxial	1.69	1.46	1.66	1.53	1.47	0.12
	Adaxial	1.69	1.26	1.71	1.77	1.54	0.21
"Long cells"							
Mean length (μ)	Abaxial	68.8	80.4	74.5	84.8	90.2	
Mean width (μ)	Abaxial	14.6	15.8	14.2	14.4	14.0	
Rippling	Abaxial	Feebly ripple-walled	Highly rippled with almost zig-zag walls	Moderately ripple-walled	Moderately rippled	Highly rippled with almost zig-zag walls	
"Short cells"							
Size and shape	Abaxial	Short Spheroidal or somewhat irregularly shaped	Large Spherical	Small Spherical	Large Spherical	Large Spherical	

The two collections received as varieties *gongylodes* and *janganika* showed almost exactly the same epidermal pattern as in Type 4 comprising the thick guinea types described earlier.

DISCUSSION

It is of interest to note that the classification of the 20 collections of *Panicum maximum* into five distinct types on the basis of morphological characters (*see* Jauhar, 1963; Jauhar & Joshi, 1966) is more or less borne out by that based on epidermal features. Although the cuticular differences in these collections of *P. maximum* were not as varied and marked as in the case of *P. coloratum* (Jauhar, 1963), yet all the morphologically-distinct types could be distinguished from one another on the basis of epidermal pattern also (Figs. 1-6) indicating that the taxon is heterogeneous to a considerable extent. Type 3, for example, is distinct from all the other types of *P. maximum* studied here with regard to the shape of the "short cells" which are exactly spherical in this type and are the smallest in size; whereas in the rest of the types the "short cells" are rather spheroidal and larger in size. Moreover, Type 3 has almost the highest number of stomata per unit area on the adaxial as well as on the abaxial epidermii (Table I). Further, the characters of the walls of "long cells", e.g., degree of rippling, the number of stomata per unit area and the shape and size of short, siliceous cells, which differentiated some species of *Panicum* (*see* Jauhar, 1967) demarcated some of these types of *P. maximum* also.

It is thus clear that epidermal patterns may serve as supplementary guides in the taxonomic classification of some taxa of Gramineae. As early as 1875, Duval-Jouve found that the type and form of epidermal cells could be of great value in classification. Later, Avdulov (1931) in his classification of the Gramineae took note of the work on the morpho-anatomy of grass leaves done by Duval-Jouve. More recently, the usefulness of foliar epidermal pattern and anatomy in taxonomic classification has been further demonstrated by Borrill (1961) in *Dactylis*, by Lea and Reynolds (1961) in Andropogoneae, by Leigh (1961) and Roy (1963) in *Eragrostis* and by Wu (1962) in Bambuseae. The diagnostic value of some features of epidermal pattern in some species of *Panicum* has also been described earlier (Jauhar, 1967).

From the foregoing discussion it is clear that epidermal patterns can serve as a useful supplementary tool in taxonomic classification of different species and also of the infra-specific taxa of Gramineae.

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